Satellite Communication Systems
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Lecture – 12
Link Budget-2

We continue our discussion. We were talking about the link budget particularly the power part of it, we will discuss about the noise much later. We have seen that we transmit the power from a source and which may have some gain, so the transmitted power and the gain put together we termed it as a effective isotropic radiated power and when the gain is maximum in that direction at a distance r and with a receive antenna whose effective aperture or gain is known so you have calculated the receive power.

And we have described because of the distance there is some sort of a reduction of the power. So, though it is not (Refer Time: 01:08) loss is still called a it a loss because it is the reduction of power and that loss is due to the path length so it termed it as a path loss. But then we were further discussion that the power received may be reduced due to other practical reasons. Those will listed as other losses and in that other losses we have discussed about the antenna depointing, because if the transmit antenna receive antenna are both sides are not aligned properly any one of them or both of them if they are miss aligned, so based on that misalignment there will be some losses because the antenna gain is not constant over complete theta or complete phi.

Then we try to some model and estimate for a small deviation small angle of depointing what should be that depointing loss. And subsequently we have discussed about that the power which is transmitted from the transmitter amplifier to the antenna which is radiating, there are certain cables, connectors, bands, adopters etcetera may come which may introduce some sort of a loss which we call termed it as a feeder loss. Now let us go into the other type of losses.

Now the power is transmitted from the antenna and it is being received at the receiver and in case of these satellite communications which is communicating between earth and satellite there is a medium which is coming in.

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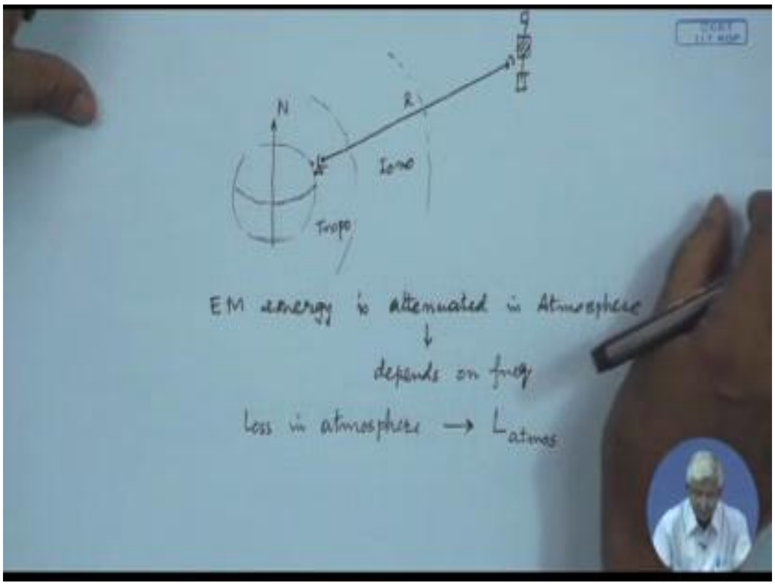

So let us try to draw very briefly, let us call it earths with a north this side and equator let us say here and there is say - location where our small antenna is put. And there is a satellite high up in the orbit which may be geosynchronous this is the satellite; satellite also has the antenna facing earth it is rotating in geo stationary geo synchronous orbit around equate. Depending on this location the distance earth path we have calculated earlier this is r, but then in between near the earth there is that atmosphere which has troposphere and higher up there are ionosphere, subsequently there will no gas or no particles which will be freespace.

Though this distance is much larger, this troposphere ionosphere may contain certain particles. At ionosphere there are electrons we can call it particles for a timing electrons and ions and that electromagnetic wave will interact with them. Similarly, at troposphere there will be water droplets, ice, dust too many particles may be there and that also will interact with electromagnetic wave. So, these electromagnetic wave may be the input which is coming and the output which will come out of the medium would be less and this is due to the (Refer Time: 04:43) energy is absorb by some of the particle, it may be scattered by the some of the particle. So, because of that what is happening is some loss is attenuation. So, EM energy is attenuated generally, we call in atmosphere. And this attenuation is depends on the frequency of operation.

We will discuss in detail about this when we talk in our propagation medium, right now we will just assume that there is certain attenuation which depends on the frequency and this is loss in atmosphere we termed it as a L atmos. So there is a loss, that loss will depend on frequency it may be large it may be small those things will discuss detail, but there is atmospheric loss. What the other loss is that can come that we have very briefly talked about something called polarization.

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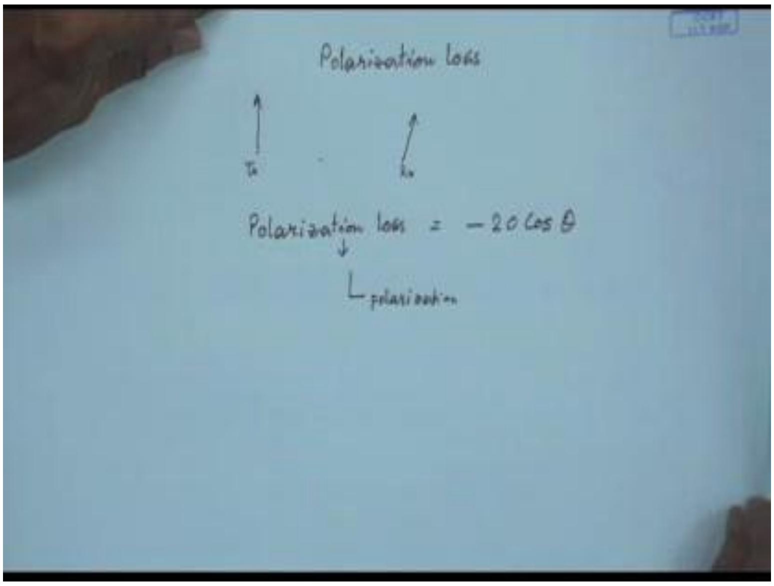

So there is a polarization loss, that is if there is a transmit polarization transmitter e field vector let us say it is vertically polarized and the receive antenna polarization is not properly adjusted, so it may have certain angle. This transmit polarization, this is receive antenna polarization. So, because of that there will be mismatch of this wave plane will have some loss it is called Polarization loss. In some of the books it says it is of the order of minus 20 cos of theta and the theta is the angle between these two planes. So, will term it as L polarization; this system as L polarization.

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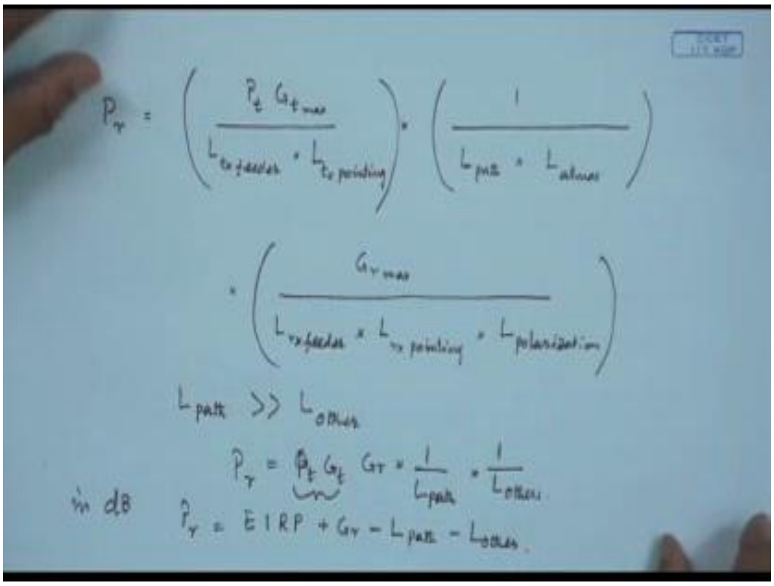

With all this losses then that can be group together and let us see how the expression then becomes. We have Pr which is equal to EIRP Pt into Gt and at the transmit side we have loss due to transmit feeder then loss due to transmit antenna pointing, and then we have the medium which is coming between and the medium there is the path distance so there is a loss due to path. Then loss due to atmosphere, and then we have the receiver where the receive antenna comes into picture.

And we are assuming that g t is max and g r is also max that is both side value will take and then there is a loss due to receive feeder, then loss due to receive antenna pointing, then there is a loss due to polarization. This is the transmit side, this is the medium this is receive side. Now in all these losses we know that path distance is quite large. So, loss due to path is much more or path loss is much more than all other losses put together is a much smaller you can consider, but it is comparatively smaller. In short now we can write that Pr is equal to Pt Gt into Gr into 1 by loss up due to paths and 1 by loss due to others.

In dB term the whole thing can be written as Pr is equal to EIRP this EIRP then plus Gr this in dB minus loss due to paths that is path loss minus loss due to others. You can see in dB terms it is only addition or subtraction. So, if these numbers are properly calculated you can draw a power level diagram.

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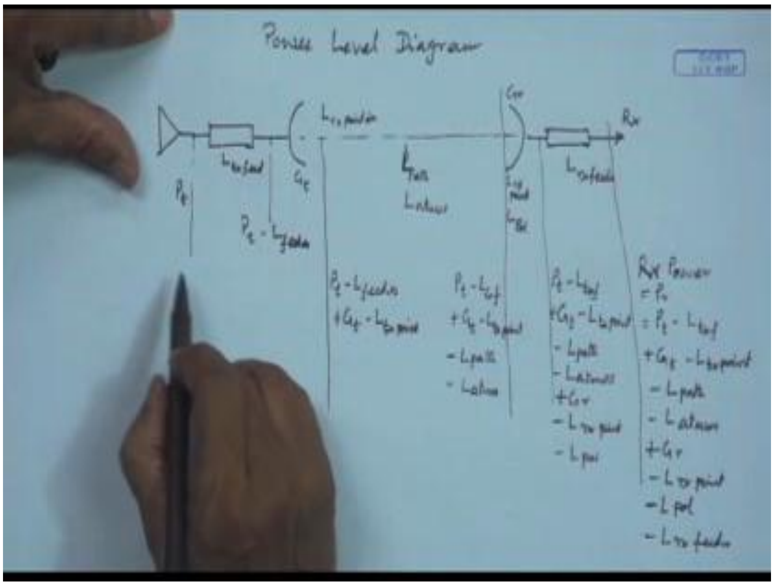

It may be like this that is we have the transmitter power amplifier and then there is some loss that is feeder loss, then there is the transmit antenna and then at a distance we have receive antenna and then there is feeder loss and then it goes to receiver. So, we can say that this is Pt and at this point because it is loss due to transmit feeder, so this will be Pt minus loss due to feeder. At this point there are other losses which are coming and gain is also coming, so here it is transmit antenna gain and then there are losses due to transmitter pointing.

So, at this point you can see it is Pt minus L feeder plus Gt which is Gt max minus L transmitter point. Now before it reaches the receive antenna we have the loss due to the path and sorry, loss due to path and loss due to atmosphere. That can be adjusted, so you can say Pt minus loss due to transmit feeder plus Gt max minus loss due to transmit pointing minus loss due to path minus loss due to atmosphere. And then here we have antenna gain that is Gr and the loss due to receiver pointing, and loss due to polarization. So, those things can be listed that is Pt minus loss due to transmit feeder plus Gt minus loss due to transmit pointing minus loss due to path minus loss due to atmosphere plus

Gr minus loss due to received pointing minus loss due to polarization. And then after that the further loss that is loss due to receive feeder whole thing, so receive power is equal to Pr will be Pt minus L transmit feeder plus Gt minus L transmit pointing minus loss due to paths minus loss due to atmosphere plus Gr minus loss due to receive pointing receive antenna pointing minus loss due to polarization minus loss due to receive feeder.

A diagram can be drawn that is based on these numbers and these vertical lines could be the power in dB, so you can see how it is varying and it is going. This is a engineer sometimes draw this diagram so that it comes clearly that where the losses are increasing or decreasing if it is in a pictorial form or graphical form other is there already expressions are already available you can calculate it also from that also. With this let us go from the power to the noise before, but that will try to give you certain assignments and in the assignment some of the sums that will come will try to see that how the antenna diameter; as I said that path loss is a quite large if you go on changing the receive antenna diameter how much is the effect on the transmit antenna diameter if I take the down link that is satellite antenna the other way is also true though, since are in the problem.

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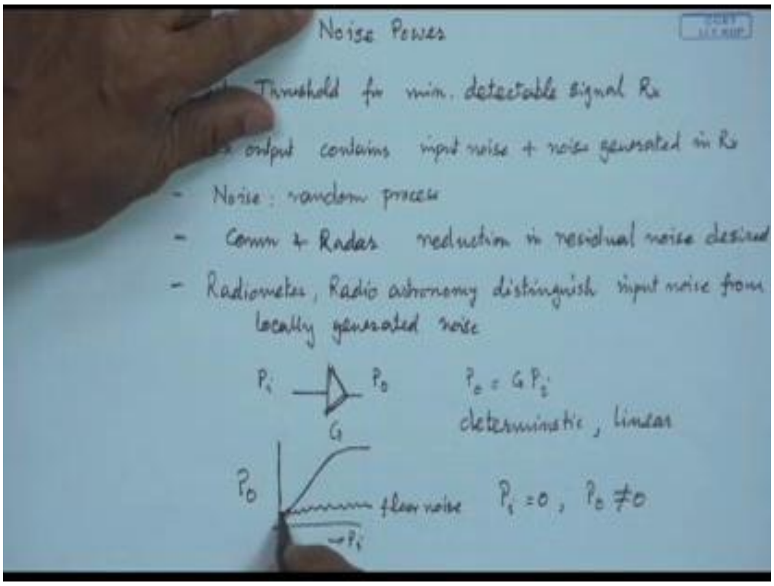

Now let us go into another part of the subject which is called the noise power. Just now what we covered is the signal part of the power now will go into the noise part of the power. This is very important, this noise power is a quite critical and actually it sets threshold for minimum detectable signal; it sets threshold for the minimum detectable signal for the receiver. The receiver will have certain capacity to detect the signal out of noise, so the noise level that determines what maybe the minimum detectable signal.

Now the receiver output will have contains the input noise plus noise generated in receiver will see into in the detail. The noise it is a random process means mainly in most of the components and in the medium also let us say electron. Electrons are vibrating and attaining the position based on the temperature it is excited and because of that electron movement the certain kinetic energy creates certain voltage which depends on the temperature which may happen in the medium or in the component itself. So, this noise is very important for us to know.

But in communication and radar this reduction in I should say residual noise there will be solve some noise always residual noise is desired, whereas there are other systems which is called radiometer or in radio astronomy which actually measures the noise level. So, there has to be that this has to distinguish input noise from locally generated noise. The input noise is what is important for radiometer and radio astronomy anyway we are interested in reduction of residual noise or just try to understand how the noise comes into picture.

Let us take an example that there is an amplifier, there is a power input and power output. This particular subsystem has a gain G. So, generally we say that power output is equal to G times the power input the assumption it is a deterministic and it is a linear process. But if you look at antenna amplifier characteristics it goes linearly and then it saturates, but this linearly does not start at 0. This is the base noise or floor noise; this is a term which is used. That means, at pi is equal to 0 when there is no input Po is as per this expression Po is suppose to be 0 for a finite gain, but Po is not equal to 0, there is some value here that is the noise which is generated inside the amplifier.

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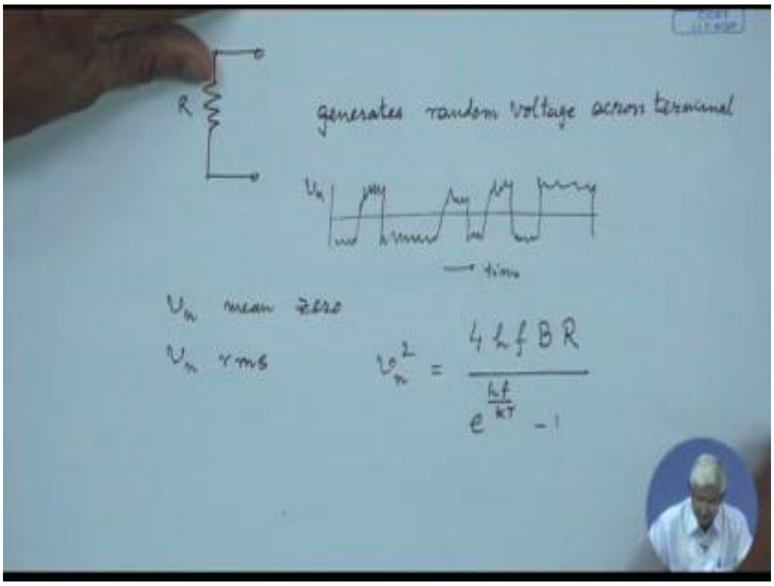

Now, let us look at it in more detail how it comes and how it can be measured the value can be estimated. Let us take a resistance; this is resistance R at a temperature T degree Kelvin. Now the electrons in side this resistance because of the temperature which is non zero it will have certainly random movements and till have certain kinetic energy, the kinetic energy will be proportional to the temperature T as we increase the T that random movements are much more. So, it generates a random voltage across terminal, and that voltage if we try to draw with time; this v n.

With average v n the mean value is 0, but there is a v n rms value which is given by if you remember in our physics course it is v n square that is a blank black body radiation which v n square is equal to 4 into h f B R by exponential e to the power hf by kt minus 1. Now, there are lots of constants and other things let us list it separately.

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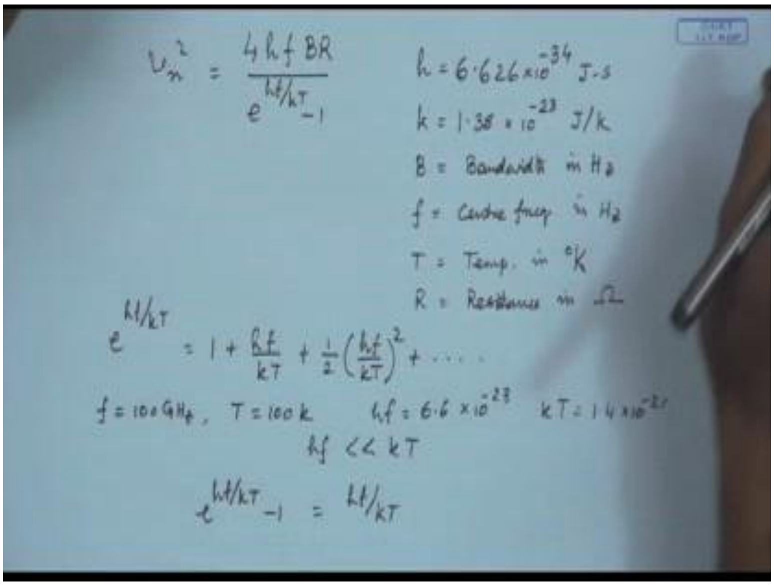

Let us say again repeat v n square is equal to 4 h f B R by e to the power hf by kt minus 1. Where, h is the blank constant is value is 6.626 into 10 to the power minus 34 joule second, k is the (Refer Time: 25:01) constant 1.38 into 10 to the power minus 23 joule per Kelvin, B is the bandwidth in hertz careful look at the units carefully, f is the center frequency of the bandwidth in hertz, T is the temperature in degree Kelvin and R is the resistance.

Now if you put into tailor series is the denominator part let us say e to the power hf by kt it is 1 plus hf by kt plus half of h f by kt square plus like that. Now at a higher frequency let us say for micro frequency f is equal to 100 Giga hertz and let us say t is equal to 100 Kelvin, the value of hf is 6.6 into 10 to the power minus 23 and value of kt 1.4 into 10 to the power minus 21, so that means hf is smaller than kt, so higher terms can be neglected. So, therefore, we can say e to the power hf by kt minus 1 is equal to hf by kt.

Since the time is over we stop here will continue the discussion in the next period.